

# Trading Market Access for Competition Policy Enforcement

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## Abstract

Motivated by discussions in the World Trade Organization (WTO) on multilateral disciplines with respect to competition law, we develop a two-country model that explores the incentives of a less developed country (LDC) to offer increased market access (via a tariff reduction) in exchange for a ban on foreign export cartels by its developed country (DC) trading partner. We show that such a bargain is feasible and can generate a globally welfare maximizing outcome. We also explore the incentives for bilateral cooperation when the LDC uses transfers to “pay” for competition enforcement by the DC. A comparison of the two cases shows that there exist circumstances in which the stick (i.e. the tariff) is more effective in sustaining bilateral cooperation than the carrot (i.e. the transfer). Furthermore, the scope for cooperation is maximized when both instruments are utilized. An implication of the analysis is that LDCs have incentives to not bind tariffs in the absence of an explicit WTO prohibition of export cartels.

Keywords: Market Access, Export Cartels, Oligopoly, Development

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## 1. Introduction

Competition concerns have been on the multilateral agenda for many years. The draft of the charter to create an International Trade Organization (ITO) in the late 1940s included a chapter on competition, reflecting concerns – driven by German cartels and Japanese *zaibatsu* in the pre-war period – that international cartels and restrictive business practices can block market access. In the 1970s an active discussion took place in the UN-context on the need to discipline restrictive business practices by multinational enterprises. Renewed attention emerged in the 1980s due to perceptions that restrictive distribution practices and conglomerates in Japan (*keiretsu*) impeded access to markets. In the 1990s, disputes between competition authorities on ‘mega-mergers’ (such as Boeing-McDonnell Douglas) led to additional calls for multilateral disciplines on competition policy (Evenett, 2002).

In 1997 a Working Group was established in the World Trade Organization (WTO) to investigate the relationship between trade and competition policies, and negotiations are likely to be launched at the 2003 WTO ministerial meeting.<sup>1</sup> There is general agreement that national competition law enforcement (or non-enforcement) can generate international pecuniary externalities. Such spillovers may arise for a number of reasons, but most frequently analyzed in the literature are ‘terms-of-trade’ effects. For example, firms may raise prices in export markets through the formation of a cartel or exercise increased market power in foreign markets through mergers. Similarly, weak antitrust enforcement on the import side may allow incumbent firms to block or attenuate foreign competition, for ex-

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<sup>1</sup>See Evenett (2002), Fox (1997), Hoekman and Mavroidis (2003) and Holmes (2002) for further discussion of the issues and state of play in the WTO.

ample, by restricting access to distribution systems. Due to such possibilities, it is well recognized that the market access and price effects of national competition policies offer a potentially compelling rationale for the inclusion of competition law disciplines into the WTO (Bagwell and Staiger, 2002). To date, the theoretical literature on competition policy and trade has mainly tended to focus on the relationship between trade and competition policy (complements versus substitutes) and on the incentives for cooperation that arise in the presence of international mergers (see Dixit, 1984, Horn and Levinsohn, 2001, Bagwell and Staiger, 2001, and Richardson, 1999, for prominent examples). This literature has shown that there is no simple relationship between trade and competition policy and that international mergers can result in rent-shifting thereby giving rise to distributional tensions and providing a motivation for international cooperation.

In this paper we argue that the presence of export cartels, a relatively neglected dimension of competition policy, may require multilateral disciplines in order to alleviate international externalities.<sup>2</sup> Empirical evidence indicates that the presence of export cartels is potentially an important issue for developing countries. In the 1990s, both the European Union (EU) and the United States (US) investigated a number of cartels in industries such as vitamins, steel, and animal feeds. The cartels that were identified often affected more than one national market. Levenstein, Oswald and Suslow (2002) analyze the purchases of developing countries of sixteen goods whose supply was found to internationally cartelized by European and/or American enterprises at some point during the 1990s. They found that in 1997 developing countries imported US\$36.4 billion of goods from a

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<sup>2</sup>Auquier and Caves (1979) and Brander and Spencer (1984) explicitly dealt with export cartels. We build on this line of research by focusing on the incentives for international cooperation that arise in the presence of export cartels.

set of 10 industries that had seen a price-fixing conspiracy during the 1990s. These imports equalled 2.9 percent of total developing country imports and 0.7 percent of their gross domestic product (GDP). Other cartel-type arrangements that have serious detrimental effects on developing countries include international air and maritime transport cartels (Francois and Wooton, 2001). Such cartels have been found to raise prices significantly for developing country shippers and consumers. Fink et. al. (2001) estimate that restrictive trade and anti-competitive practices raise maritime liner transport costs by up to \$3 billion on goods carried to the US.

In principle, national competition authorities could invoke domestic antitrust law against foreign export cartels. However, many developing countries have limited ability to follow this course of action. Recognition of capacity constraints in developing countries therefore provides a possible motivation for international co-operation regarding export cartels. If developing countries are not able to combat anti-competitive behavior of foreign firms in their markets, or can only do so at high cost, one solution is for developed WTO members to agree to prohibit firms in their jurisdictions from colluding and raising prices in developing countries (Hoekman and Mavroidis, 2003). Such a policy action would avoid implementation costs for developing country governments while addressing the negative externalities they suffer from the anti-competitive behavior of developed country exporters.

In effect, such an outcome is equivalent to the grant of “in kind” development assistance, as it comes at a cost to the developed country. While such “aid” would be first best from a world welfare point of view, in practice developing countries will have to pay for such a commitment on the part of developed countries. WTO

negotiations are driven by reciprocity, not altruism. Thus, an important policy question is whether developing countries can induce developed countries to discipline anti-competitive behavior of their exporting firms. In practice the quid pro quo most likely would have to take the form of market access concessions. On the other hand, market access restrictions may also be the major instrument developing country governments have to respond to foreign cartelization. The following questions follow immediately: (i) Is a bargain linking trade policy (market access) commitments by developing countries to antitrust enforcement by developed countries (a ban on export cartels) feasible? (ii) Are there alternative solutions (such as transfers) that can help support a globally efficient outcome? (iii) If so, how do market access restrictions (implemented via tariffs) compare with transfers in terms of helping to sustain the efficient outcome?

We develop a simple two-country model to answer these questions. In our model, a less developed country (LDC) that does not have the capacity to enforce national antitrust law against foreign exporters from a developed country (DC) is confronted with the possibility of cartelization by those exporters. We focus on the incentives the LDC has to trade market access (via a tariff reduction) for competition policy enforcement by the DC where such enforcement prohibits cartelization by DC firms. In addition, we compare this scenario with a situation where the LDC can ‘buy’ competition law enforcement from the DC through a transfer of some kind, as well as a situation where both instruments (i.e. a tariff and a transfer) can be used. We show that the latter maximizes the scope for cooperation and that the required transfers are less if the LDC can limit market access via a tariff (or other trade policy instruments).

Our results suggest a rationale for developing countries not to bind tariffs in

the WTO. Absent the first best outcome of a unilateral decision by developed countries to apply national antitrust extraterritorially to defend the interests of consumers in developing countries against anti-competitive behavior of their firms on these markets, we conclude that there is a good case for adopting a binding prohibition on the formation of export cartels in the WTO. Such a ban would make developing countries more willing to reduce and bind their tariffs since they could then rely on the multilateral dispute settlement procedure to enforce the ban.

The remainder of the paper is organized as follows. Section 2 presents the policy game between the two countries. Section 3 considers the infinitely repeated version of the basic game and explores the incentives for bilateral cooperation. The next two sections explore the role transfers play in sustaining cooperation. Section 6 examines the robustness of our arguments for the case of price competition. Section 7 concludes while section 8 presents the supporting calculations.

## 2. Basic Model

We consider a two country world comprised of a developed country (indexed by subscript  $D$  and referred to as the DC) and a less developed country (indexed by subscript  $L$  and referred to as the LDC). There are two goods ( $x$  and  $y$ ) and preferences in the LDC over these goods are quasi-linear:  $U(x, y) = u(x) + y$ . Good  $y$  is the numeraire good produced under perfect competition with constant returns to scale technology in both countries. There are  $n$  DC firms that produce good  $x$ , where  $n \geq 2$ . The marginal cost of production of each firm equals  $c$ , where  $c \geq 0$ . The DC imports good  $y$  from the LDC and exports good  $x$  in return.

Let  $t$  denote the tariff imposed by the LDC on its imports of good  $x$ . This tariff is endogenously determined (see below). We assume that firms are organized enough to successfully cartelize production so long as the DC government permits them to do so. The LDC does not have the infrastructure to prevent the export cartel from charging high prices. As we explain below, the only way the LDC can punish cartelization is to limit market access via a tariff (if it is optimal to do so).

To focus on the “pure” case for cooperation on the basis of consumer welfare, we assume that good  $x$  is produced only by the DC and consumed only in the LDC. In an early paper, Auquier and Caves (1979) had noted that the cartelization of an export industry might not raise domestic welfare if the cartel also raises prices at home. However, it is worth noting that antitrust laws in many developed countries (such as the United States) permit their firms to form export cartels only if they do not raise prices at home. If the DC were to enforce such a condition on its export cartel, permitting consumption of good  $x$  in the DC would not alter our analysis. Assuming no domestic production of good  $x$  in the LDC allows us to ignore possible strategic trade motives for tariffs.<sup>3</sup>

Consider the following two stage policy game. In the first stage, the two countries simultaneously make their policy decisions: the DC decides whether or not to permit its firms to form an export cartel while the LDC chooses the level of its tariff. Given the policy choices of the governments, DC firms decide how much to export and consumption takes place. We next derive the sub-game perfect equilibrium of this game. To facilitate analytical derivations, assume that  $u(x)$  is

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<sup>3</sup>The assumption also implies the LDC may have no incentive to create a domestic antitrust agency.

quadratic so that the (inverse) demand curve for good  $x$  in the LDC is given by:

$$p = a - \sum_i x_i(t) \quad (2.1)$$

where  $x_i$  denotes the exports of a typical DC firm  $i$ .

### 2.1. The LDC's Tariff Response

To obtain a subgame perfect Nash equilibrium, we solve the model backwards. Suppose the DC does not permit its firms to form an export cartel. In such a situation, firms compete in the LDC market, given the LDC tariff  $t$ . Firm  $i$ 's first order condition is given by  $p + p'x_i = t + c$ . Since firms are symmetric, in equilibrium, we have  $x_i = x$  for all  $i$ . Let  $X = nx$  denote the total output of good  $x$  sold in the LDC.

At the trade policy stage, the LDC chooses its tariff to maximize its own welfare defined as the sum of consumer surplus and tariff revenue. It solves:

$$\text{Max}_t W_L(t) \equiv u(X) - pX + tX \quad (2.2)$$

Using the consumer optimization condition  $u'(X) = p$ , the first order condition for the above problem can be written as:

$$\frac{\partial W_L}{\partial t} = -p' \frac{\partial X}{\partial t} X + X + t \frac{\partial X}{\partial t} = 0 \quad (2.3)$$

Using equation (2.1), the above equation becomes

$$\frac{\partial W_L}{\partial t} = -\frac{nX(t)}{n+1} + X(t) - \frac{nt}{n+1} = 0 \quad (2.4)$$

which yields  $nt = X(t)$ . This equation defines the optimal LDC tariff  $t^*$ . Note that as long as  $X(t^*) > 0$  it must be that  $t^* > 0$ . In fact, using equation (2.1), we



can show that:

$$t^* = \frac{\alpha}{n+2} \text{ where } \alpha \equiv a - c > 0. \quad (2.5)$$

**Lemma 1:** *The LDC's optimal tariff  $t^*$  on good  $x$  is positive and it decreases with the number of competing DC firms.*

Lemma 1 is not a surprise: the result that an importing country's tariff generally increases with the concentration level of the exporting country was shown by Brander and Spencer (1984). Intuitively, since the purpose of the tariff is to extract rents from DC exporters, as the mark-up charged by them shrinks the LDC's incentive to extract rents also diminishes. An important implication of lemma 1 is that if the DC were to permit its exporting firms to cartelize, then the tariff imposed by the LDC would increase thereby undermining the effectiveness of the export cartel. Let  $t^c \equiv t^*(n=1) = \frac{\alpha}{3}$  be the optimal tariff under cartelization by the DC exporters, where  $t^c > t^*$  for all  $n \neq 1$ .

## 2.2. Competition versus Cartelization

The objective of the DC is to maximize the profits of its exporters. Given this, it is immediate that in the simultaneous move game, the DC would always permit cartelization given the tariff rate chosen by the LDC. Thus, in equilibrium, the DC approves cartelization and the LDC imposes the optimal tariff  $t^c$ . However, such an outcome constitutes a Prisoner's dilemma for a large range of parameter values. To see this, consider two different outcomes: one in which the DC does not permit cartelization and the LDC imposes the tariff  $t^*$  and another in which it permits cartelization and the LDC imposes the tariff  $t^c$ . The first scenario is denoted by the pair  $(n, t^*)$ , the second by  $(1, t^c)$ .

It is easy to show that the LDC prefers competition  $(n, t^*)$  to cartelization

$(1, t^c)$  since

$$\frac{\partial W_L(t^*(n), n)}{\partial n} = \frac{\alpha^2}{(n+2)^2} > 0.$$

Thus, the increase its optimal tariff in response to cartelization is not sufficient to make cartelization more attractive than competition to the LDC.

Given the tariff response of the LDC, the DC prefers competition  $(n, t^*)$  to cartelization  $(1, t^c)$  iff

$$\pi(1, t^c) < n\pi(n, t^*) \Leftrightarrow \frac{\alpha^2(n-1)(n-4)}{9(n+2)^2} < 0 \Leftrightarrow n < 4$$

**Proposition 1:** *The DC prefers competition amongst its exporting firms under the (low) LDC tariff  $t^*$  to cartelization of its exporting firms subject to the high tariff  $t^c$  iff  $n < 4$ .*

Proposition 1 informs us that cartelization subject to the high tariff  $t^c$  is not preferable to the DC if its market structure is relatively concentrated. On the other hand, when market structure in the DC is highly competitive, cartelization results in a large increase in profits and is attractive to the DC even if it is accompanied by a high rent extracting tariff. Thus, cartelization combined with a higher tariff is a Prisoner's dilemma when  $n < 4$ . Of course, aggregate world welfare is always higher under competition combined with the (low) tariff  $(n, t^*)$  than it is under cartelization subject to the high tariff  $(1, t^c)$ .

Below, we explore whether the socially desirable outcome can be sustained under repeated interaction between countries. To do so, we study the infinitely repeated version of our policy game.

### 3. Repeated Interaction

Following the paradigm in the literature, cooperation between the two countries is modelled as a stationary repeated game where cooperation can be sustained only if it is incentive compatible for both countries. Under this approach, each country weighs the benefit of defecting from cooperation against the future cost of such defection.

Repeated interaction provides the two countries with the opportunity to cooperate over free trade. By contrast, under one time interaction, the lowest (credible) tariff the LDC imposes equals  $t^*$ . Thus, it is natural to examine the scenario where the LDC imposes a zero tariff under competition as opposed to its optimal tariff  $t^*$ . Under cooperation, the DC does not permit cartelization and the LDC imposes no tariff on the DC's exports. By assumption, countries sustain cooperation via trigger strategies and defection by any country results in a *policy war* wherein both countries revert to their Nash equilibrium policies: the DC permits cartelization while the LDC imposes the tariff  $t^c$ .

#### 3.1. Incentive Constraints under a Tariff

Sustained bilateral cooperation over competition (on the part of the DC) and free trade (on the part of the LDC) requires that the (current) benefit of defection be dominated by the future cost of defection for both countries. The per period welfare of the DC under cooperation equals the total profits of its exporting industry under free trade  $n\pi(n, 0)$  whereas its welfare under defection equals  $\pi(1, 0)$  – the profits of its export cartel under free trade. Defection by the DC is punished by the LDC via the imposition of the tariff  $t^c$  for all future periods. Thus,

cooperation is incentive compatible for the DC iff

$$\pi(1, 0) - n\pi(n, 0) \leq \frac{\delta}{1 - \delta} [n\pi(n, 0) - \pi(1, t^c)]$$

where  $\delta$  denotes the discount factor. The above incentive constraint is the same as

$$(1 - \delta)\pi(1, 0) + \delta\pi(1, t^c) \leq n\pi(n, 0) \quad (3.1)$$

which can be written as

$$\frac{(1 - \delta)\alpha^2}{4} + \frac{\delta\alpha^2}{9} \leq \frac{n\alpha^2}{(n + 1)^2} \quad (3.2)$$

The above constraint binds at  $\delta_D^*$  where

$$\delta_D^* = \frac{9(n - 1)^2}{5(n + 1)^2} \text{ where } \frac{d\delta_D^*}{dn} = \frac{36(n - 1)}{5(n + 1)^3} > 0. \quad (3.3)$$

**Proposition 2:** *Bilateral cooperation over free market access in return for prohibition of an export cartel is acceptable to the DC iff  $\delta \geq \delta_D^*$ . Furthermore, as the market structure in the DC becomes more competitive, its willingness for bilateral cooperation decreases.*

The intuition behind the proposition is clear: when the DC market is very competitive, cartelization is highly attractive to the DC and the lure of free market access fades in comparison to the increase in rents that cartelization brings.

Now consider the viewpoint of the LDC. Let  $X^0$  denote total output sold in the LDC under free trade and competition, and  $p^0$  the associated price:  $X^0 \equiv X(n, 0)$  and  $p^0 \equiv p(X^0)$ . The per period welfare of the LDC under cooperation equals total consumer surplus in its market under the price quantity combination  $(p^0, X^0)$ :

$$W_L^0 \equiv u(X^0) - p^0 X^0$$

Let  $(p^*, X^*)$  denote the price quantity pair under competition and the optimal LDC tariff  $t^*$ :  $X^* \equiv X(n, t^*)$  and  $p^* \equiv p(X^*)$ . The LDC's welfare under defection equals the sum of consumer surplus and tariff revenue under the pair  $(p^*, X^*)$  and its optimal tariff  $t^*$ :

$$W_L^D \equiv u(X^*) - p^* X^* + t^* X^*$$

Defection by the LDC results in a policy war wherein the DC permits export cartelization and the LDC imposes the tariff  $t^c$ . Let the pair  $(p^c, X^c)$  denote the price quantity pair under the policy war, where  $X^c \equiv X(1, t^c)$  and  $p^c \equiv p(X^c)$ . The LDC's welfare under the policy war equals

$$W_L^W \equiv u(X^c) - p^c X^c + t^c X^c$$

Cooperation is incentive compatible for the LDC iff the following incentive constraint is satisfied:

$$W_L^D - W_L^0 \leq \frac{\delta(W_L^0 - W_L^W)}{1 - \delta} \Leftrightarrow (1 - \delta)W_L^D + \delta W_L^W \leq W_L^0 \quad (3.4)$$

Using equation (2.1), this constraint can be written as

$$\frac{(1 - \delta)n\alpha^2}{2n + 4} + \frac{\delta\alpha^2}{6} \leq \frac{n^2\alpha^2}{2(n + 1)^2} \quad (3.5)$$

The above constraint binds at  $\delta_L^*$  where

$$\delta_L^* = \frac{3n}{2(n + 1)^2(n - 1)} \text{ where } \frac{d\delta_L^*}{dn} = -\frac{3}{2} \frac{n(2n - 1) + 1}{(n + 1)^3(n - 1)^2} < 0. \quad (3.6)$$

**Proposition 3:** *Bilateral cooperation over free market access in return for prohibition of an export cartel is acceptable to the LDC iff  $\delta \geq \delta_L^*$ . Furthermore, as the market structure in the DC becomes more competitive, the LDC's willingness for bilateral cooperation increases.*

When the DC market is relatively competitive, cooperation is attractive to the LDC because preventing cartelization implies a large increase in consumer surplus. Figure 1 illustrates the critical discount factors for the two countries as a function of number of firms ( $n$ ) in the market.

The DC's critical discount factor  $\delta_D^*$  is upward sloping whereas that of the LDC (i.e.  $\delta_L^*$ ) is downward sloping. The upward sloping DC constraint reflects the fact that as market structure becomes more competitive, the discount factor needs to be still higher for it to be willing to cooperate. The DC's incentive to cheat and permit cartelization is strong when market competition is fierce and for it to not do so, it needs to value the future highly. The LDC's critical discount factor  $\delta_D^*$  is upward sloping exactly for the same reason: as the market structure in the DC becomes more competitive, its incentive to cheat declines and the required discount factor needed to sustain cooperation falls.

Figure 1 can be divided into four regions: I, II, III, and IV. In region II, bilateral cooperation succeeds because the incentive constraints of both countries are satisfied due to the discount factor  $\delta$  being relatively large. In region I, while the DC is willing to cooperate, the LDC is not. In region III, the opposite is true. The LDC refuses cooperation in region I because the market structure in the DC is highly concentrated and the discount factor is relatively small – here, cartelization does not hurt the LDC that much and it values the ability to extract rents via a tariff relatively more than the prohibition of cartelization by the DC. Finally, in region IV, neither country is willing to cooperate because the discount factor is too small to make cooperation worthwhile.

Thus far the analysis assumes that the LDC has the ability to restrict access to its market via a tariff. However, many tariffs are bound under GATT rules.

As a result, the freedom to control access via a tariff may not be always available. Indeed, one objective of the WTO is to reduce tariffs, in effect ultimately removing access to this instrument. In the next section we consider how a LDC might be able to ‘buy’ competition policy enforcement via a transfer to the DC. We do not require that the transfer always go from the developing to the developed country – who pays whom is determined in equilibrium.

## 4. International Transfers

Suppose the LDC must practice free trade due to GATT obligations. In such a situation, can bilateral cooperation be sustained via the use of a per period transfer  $T$  from the LDC to the DC (which may be  $< 0$ )? In each period, both countries simultaneously decide whether to cooperate or not. If the LDC chooses to cooperate, it pays its per period transfer  $T$  whereas if it chooses to defect, it does not make the payment to the DC. Similarly, the DC prohibits cartelization under cooperation and permits it under defection.

### 4.1. Incentive Constraints under a Transfer

The per period welfare of the DC under cooperation equals the sum of the total profits of its exporting industry under free trade and the transfer it receives from the LDC:  $n\pi(n, 0) + T$ , whereas its welfare under defection equals the sum of the profits of its export cartel under free trade and the transfer  $T$ :  $\pi(1, 0) + T$ . If the DC defects, the LDC stops paying the transfer  $T$  from next period on and the DC simply collects the exporting profits from cartelization,  $\pi(1, 0)$ . Thus, cooperation

is incentive compatible for the DC iff the following incentive constraint holds:

$$[\pi(1, 0) + T] - [n\pi(n, 0) + T] \leq \frac{\delta}{1 - \delta} [n\pi(n, 0) + T - \pi(1, 0)]$$

which is the same as

$$\pi(1, 0) - n\pi(n, 0) \leq \delta T \quad (4.1)$$

In other words, the DC is willing to cooperate iff the per period LDC transfer  $T$  exceeds the critical threshold  $T_D^*$ :

$$T > T_D^* \equiv \frac{\pi(1, 0) - n\pi(n, 0)}{\delta} = \frac{\alpha^2(n-1)^2}{4(n+1)^2\delta} > 0 \quad (4.2)$$

Now consider the LDC's perspective. The current benefit of defection to the LDC is that it saves the international transfer  $T$ . The future cost of defection is that it forever faces an export cartel. Let  $(p^{W0}, X^{W0})$  denote the price quantity pair under cartelization with zero tariff:  $X^{W0} \equiv X(1, 0)$  and  $p^{W0} = p(X^{W0})$ . The LDC's welfare under the policy war equals

$$W_L^{W0} \equiv u(X^{W0}) - p^{W0}X^{W0}$$

The LDC is willing to cooperate iff the following incentive constraint holds:

$$T \leq \frac{\delta}{1 - \delta} [W_L^0 - T - W_L^{W0}] \quad (4.3)$$

The above constraint implies that the LDC is willing to cooperate iff the per period transfer  $T$  is below the critical threshold  $T_L^*$ :

$$T < T_L^* \equiv \delta(W_L^0 - W_L^{W0}) = \frac{\delta\alpha^2(n-1)(3n+1)}{8(n+1)^2} > 0 \quad (4.4)$$

Note that  $T_L^* > 0$ : *in equilibrium the LDC is indeed willing to pay the DC to sustain cooperation.* Furthermore, the maximum transfer the LDC is willing to



pay increases as the market structure becomes more competitive in the DC:

$$\frac{dT_L^*}{dn} = \frac{n\delta\alpha^2}{(n+1)^3} > 0$$

However, as its market structure becomes more competitive the transfer the DC requires to prohibit an export cartel also increases:

$$\frac{dT_D^*}{dn} = \frac{(n-1)\alpha^2}{\delta(n+1)^3} > 0$$

A key question is then whether there are circumstances under which the transfer the LDC is willing to pay is acceptable to the DC? We have

$$T_L^* - T_D^* = \frac{\alpha^2(n-1)[2(n-1) - 3\delta^2(n+1)]}{8\delta(n+1)^2}$$

It follows from above that

$$T_L^* > T_D^* \text{ iff } \delta > \delta^T \equiv \sqrt{\frac{2(n-1)}{3(n+1)}}$$

In other words, the LDC's transfer exceeds that of the DC so long as the two countries are patient enough. Furthermore,  $\delta^T$  increases in  $n$ ,

$$\frac{1}{\delta^T} \frac{d\delta^T}{dn} = \frac{2}{3(n+1)(n-1)} > 0$$

*so that cooperation becomes harder to sustain as competition in the DC market increases* (recall that the same is true under a tariff).

## 4.2. Tariff versus Transfer

In this section we analyze how a tariff compares to a transfer in terms of making cooperation feasible. We refer to the scenario where the LDC has only a tariff at its disposal as the  $t$  only case and the scenario where only the transfer is available

as the  $T$  only case. In section 5, we consider the  $(t, T)$  case: i.e., when the LDC has both instruments at its disposal. The comparison between a tariff ( $t$ ) and a transfer ( $T$ ) is illustrated in Figure 2.

Figure 2 superimposes the  $T_L^* = T_D^*$  constraint on Figure 1, thus allowing a direct comparison of the two instruments. Under the  $T$  only case, cooperation can be sustained above the  $T_L^* = T_D^*$  constraint (i.e. regions V and VI in Figure 2) whereas it fails below it (i.e. regions I - IV). Recall that in the  $t$  only case, cooperation can be sustained in region II, whereas it fails in regions I, III, and IV. Thus, a comparison of the two cases indicates that relative to a transfer, a tariff makes cooperation possible in region II whereas it hinders cooperation in region VI. Thus, *one instrument does not dominate another in so far as sustaining cooperation is concerned.*

To see the intuition behind these results, consider region II in Figure 2, where a tariff succeeds in sustaining cooperation but a transfer fails. In this region, the DC market is fairly concentrated and the discount factor is relatively small. Cartelization does not hurt the LDC that much and the tariff allows it to undo some of the harmful effects of cartelization – recall that  $t^*$  decreases in  $n$ . Thus, in region II, the LDC is unwilling to make a transfer to the DC to induce it to cooperate. In region VI, cartelization is highly attractive to the DC because competition substantially erodes the rents of its exporting industry when the number of competing firms ( $n$ ) is large. As a result, it requires some compensation from the LDC to not permit cartelization. Such compensation is simply unavailable under a tariff and, in region VI, the LDC is willing to provide it under a transfer because the gain from preventing cartelization is big enough. Note also that in region VI the discount factor is relatively high and the future gains from cooperation

are valued by both parties. To summarize, when the DC market structure is relatively concentrated, the punishment effect of a tariff is more effective in sustaining cooperation. Conversely, when the DC market structure is relatively competitive, compensation via a transfer is more effective in facilitating cooperation.

## 5. Both Instruments

Suppose now that the LDC has both a tariff  $t$  and a transfer  $T$  available as instruments. As is clear, the two instruments play very different roles: the tariff acts as a stick whereas the transfer acts as a carrot. Under the  $(t, T)$  case, cooperation is incentive compatible for the LDC iff

$$W_L^D - [W_L^0 - T] \leq \frac{\delta(W_L^0 - T - W_L^W)}{1 - \delta} \Leftrightarrow (1 - \delta)W_L^D + \delta W_L^W \leq W_L^0 - T \quad (5.1)$$

This can be rewritten as

$$\frac{(1 - \delta)n\alpha^2}{2n + 4} + \frac{\delta\alpha^2}{6} \leq \frac{n^2\alpha^2}{2(n + 1)^2} - T \quad (5.2)$$

The above constraint implies that cooperation is acceptable to the LDC iff the per period transfer  $T$  lies below a critical threshold:

$$T \leq T_L^t \equiv \frac{2\delta\alpha^2n(n^2 + n - 1) - (2\delta + 3n)\alpha^2}{6(n + 1)^2(n + 2)} \quad (5.3)$$

Similarly, cooperation is incentive compatible for the DC iff

$$[\pi(1, 0) + T] - [n\pi(n, 0) + T] \leq \frac{\delta}{1 - \delta}[n\pi(n, 0) + T - \pi(1, t^c)] \quad (5.4)$$

This is the same as

$$(1 - \delta)\pi(1, 0) + \delta\pi(1, t^c) \leq n\pi(n, 0) + \delta T$$

and can be written as

$$\frac{(1-\delta)\alpha^2}{4} + \frac{\delta\alpha^2}{9} \leq \frac{n\alpha^2}{(n+1)^2} + \delta T \quad (5.5)$$

Thus, the DC is willing to cooperate iff the per period LDC transfer  $T$  exceeds a critical threshold:

$$T > T_D^t \equiv \frac{9\alpha^2(n-1)^2 - 5\alpha^2\delta(n+1)^2}{36\delta(n+1)^2} \quad (5.6)$$

Note that the DC receives a transfer iff  $T_D^t > 0$ . It is easy to show that this is the same as

$$T_D^t > 0 \Leftrightarrow \delta < \delta_D^t \equiv \frac{9(n-1)^2}{5(n+1)^2} \quad (5.7)$$

The LDC pays a transfer iff  $T_L^t > 0$  and

$$T_L^t > 0 \Leftrightarrow \delta > \delta_L^t \equiv \frac{3n}{2(n-1)(n+1)^2}.$$

Figure 3 shows the incentives for cooperation under the  $t$  only case compared to the  $(t, T)$  case. The constraint  $T_D^t = T_L^t$  (for the  $(t, T)$  case) lies below the constraint  $T_D^* = T_D^*$  (for the  $T$  only case), and the figure can be divided into three regions: I, II, and III. Cooperation can be sustained under a transfer only in region III, while under both instruments cooperation occurs in regions II and III. Thus, when the LDC has both a stick ( $t$ ) and a carrot ( $T$ ) at its disposal, cooperation is more likely. The following proposition provides further details behind this result:

**Proposition 4:** *The minimum transfer required by the DC under the  $(t, T)$  case is lower than the corresponding transfer under the  $T$  only case ( $T_D^t < T_D^*$ ). Furthermore, the LDC is willing to pay a higher transfer under the  $T$  only case relative to the  $(t, T)$  case ( $T_L^t < T_L^*$ ). Finally, even under the  $(t, T)$  case, there*

*exist parameter values for which the maximum transfer the LDC is willing to pay exceeds the minimum transfer required by the DC ( $T_D^t < T_L^t$ ).*<sup>4</sup>

The above proposition has several important implications. First, if the LDC cannot punish cartelization via a tariff (say because it is bound by GATT rules), the DC requires a higher transfer from the LDC to abide by cooperation. Second, the LDC finds itself in a weaker position when its tariff is bound and is itself willing to pay more to induce the DC to prohibit cartelization. The fact that required transfers are less if developing countries have access to the trade policy instrument provides a motivation for developing countries to *not* bind tariffs in the WTO. Obviously the same is true in the one instrument case where LDC's only have the tariff available. Thus, there may be a good case for WTO members to adopt a binding prohibition on the formation of export cartels. Such a ban would allow developing countries to move forward in reducing and binding their tariffs, as multilateral dispute settlement procedures - which ultimately can result in authorization to retaliate against violations of the rules - can be used to enforce the export cartel ban.

The last part of the above proposition shows that the LDC's lower willingness to pay a transfer under the  $(t, T)$  case does not imply that the transfer is not acceptable to the DC, as it too requires a lower transfer when the tariff is an available instrument. In fact, in Figure 3, *region II primarily obtains because the transfer required by the DC falls*. Our model is largely silent about the transfer that actually occurs in equilibrium. For example, in the one instrument  $(T)$  world, any transfer in the range  $[T_D^*, T_L^*]$  can support cooperation, as long as

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<sup>4</sup>A function analogous to  $\delta^T$  can be derived but the analytical expression for it is rather cumbersome. This function is also increasing in  $n$  and approaches 0.68 when  $n$  approaches infinity.

$T_L^* \geq T_D^*$ . Clearly, the closer is the actual transfer to  $T_L^*$  ( $T_D^*$ ), the lower would be the LDC's (DC's) welfare. The actual transfer is likely to be a function of the bargaining power of the two countries and other issue linkages that might drive trade negotiations.

Thus far, the analysis assumes that, in the absence of cartelization, firms compete in quantities (Cournot competition). What if firms compete in prices (Bertrand competition)? There are two reasons for considering how our results change when firms compete in prices. First, as is well known, results under oligopoly can be quite sensitive to the choice of strategic variable (price versus quantity). It is important therefore to know which results are general and which depend upon the nature of competition being assumed. Second, since the Nash equilibrium under price competition results in marginal cost pricing, the Bertrand case applies to a scenario where the potential cartelization of a perfectly competitive industry in the DC is considered.<sup>5</sup> In the following analysis we show that as  $n$  approaches infinity under Cournot competition, the results under Cournot competition converge to those under price (Bertrand) competition.

## 6. Price Competition

Under price competition, the equilibrium price charged by DC firms equals their marginal cost  $c$ . In our one shot policy game, the optimal LDC tariff  $t^*$  then equals zero (since there are no rents to be extracted) and its imports  $X$  would equal  $\alpha$ .<sup>6</sup> On the other hand, if the DC firms were to cartelize, the optimal LDC tariff

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<sup>5</sup>A frequently heard argument in favor of encouraging export cartels is that it such cartels would allow small and medium sized firms to compete less severely in foreign markets. Presumably, such firms are likely to be close to marginal cost pricing.

<sup>6</sup>In this situation, LDC welfare would equal total consumer surplus which is given by  $\frac{\alpha^2}{2}$ .

would exactly equal  $t^c$ . Thus, the qualitative nature of the LDC response does not change: cartelization results in an increase in the LDC tariff even under price competition. However, the two modes of competition do differ quantitatively: under Cournot competition the LDC charges a positive tariff even in the absence of Cartelization; this is not so under price competition.

Now consider the repeated game. The most important implication of assuming price competition is that even though the LDC does not impose any tariff under competition, the DC would *never* prefer competition to cartelization. The reason is simple: Bertrand competition erodes all rents, while cartelization, even if subject to the optimal LDC tariff  $t^c$ , still leaves the DC with some rents.<sup>7</sup> Thus, the threat of a tariff increase on the part of the LDC would be insufficient to induce the DC to prohibit cartelization by its firms. The Nash equilibrium would cease to be a prisoner's dilemma: the LDC would surely be worse off under cartelization relative to competition, whereas the DC would be better off. Since aggregate world welfare is lower under such an equilibrium, cooperation between the two countries in a repeated game could be sustained via a transfer but not via a tariff alone. To see this, note that the DC incentive constraint under price competition under the  $t$  only case is

$$\pi(1, 0) - n\pi(n, 0) \leq \frac{\delta}{1 - \delta} [n\pi(n, 0) - \pi(1, t^c)] \quad (6.1)$$

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<sup>7</sup>Note that if DC firms were asymmetric in terms of production costs, the DC could prefer competition under free trade to cartelization as long as one of the firms is sufficiently more efficient than its competitors. This is because even under competition, the lowest cost DC firm would monopolize the market by charging a limit price equal to the cost of its most efficient rival and earn rents because of a positive mark-up. However, the optimal LDC tariff would extract *all* such rents (it would equal the lowest cost DC firm's mark-up), and the DC would not prefer competition under the optimal LDC tariff to cartelization.

But  $\pi(n, 0) = 0$  under price competition, so that we have

$$(1 - \delta)\pi(1, 0) + \delta\pi(1, t^c) \leq 0$$

which can *never* hold since  $\pi(1, 0)$  and  $\pi(1, t^c)$  are both strictly positive.

By contrast, consider the LDC constraint in the  $t$  only case:

$$(1 - \delta)W_L^D + \delta W_L^W \leq W_L^0 \quad (6.2)$$

where  $W_L^D = W_L^0$  (because the optimal LDC tariff under price competition equals zero – since there are no rents to be extracted, a tariff merely raises price in the LDC market from  $c$  to  $c + t$  and creates a pure deadweight loss). The above constraint can be rewritten as  $\frac{\delta\alpha^2}{6} \leq \frac{\delta\alpha^2}{2}$  which *always* holds. In other words, *under the  $t$  only case, when firms compete in prices the LDC always prefers cooperation to a policy war whereas the DC never does so.*

Now consider the incentive constraints of the two countries under the  $T$  only case. For the DC, we have:

$$\pi(1, 0) \leq \frac{\delta}{1 - \delta}[T - \pi(1, 0)] \Leftrightarrow T > T_D^B \equiv \frac{\pi(1, 0)}{\delta} = \frac{\alpha^2}{4\delta} > 0$$

whereas for the LDC we have

$$T < T_L^B \equiv \delta(W_L^0 - W_L^{W0}) = \delta\left(\frac{\alpha^2}{2} - \frac{\alpha^2}{8}\right) = \frac{3\delta\alpha^2}{8} > 0 \quad (6.3)$$

It immediately follows that the LDC transfer is sufficient to induce the DC to cooperate if  $T_L^B > T_D^B \Leftrightarrow \delta > \sqrt{\frac{2}{3}} = 0.82$ . Thus, policy cooperation is possible under a transfer as long as the two countries are patient enough.

Finally, how does the scope for policy cooperation change when the LDC has both instruments at its disposal? The LDC constraint under the  $(t, T)$  case is



given by

$$(1 - \delta)W_L^D + \delta W_L^W \leq W_L^0 - T \Leftrightarrow (1 - \delta)\frac{\alpha^2}{2} + \delta\frac{\alpha^2}{6} \leq \frac{\alpha^2}{2} - T$$

The above constraint implies that the LDC is willing to cooperate iff

$$T \leq T_L^{Bt} \equiv \frac{\delta\alpha^2}{3}$$

The DC constraint for cooperation under the two instruments is given by

$$(1 - \delta)\pi(1, 0) + \delta\pi(1, t^c) \leq \delta T \Leftrightarrow \frac{(1 - \delta)\alpha^2}{4} + \frac{\delta\alpha^2}{9} \leq \delta T \quad (6.4)$$

Solving for the critical transfer  $T_D^{Bt}$ , above which cooperation is acceptable to the DC, gives

$$T_D^{Bt} = \frac{(9 - 5\delta)\alpha^2}{36\delta} \quad (6.5)$$

Thus, policy cooperation succeeds iff  $T_L^{Bt} > T_D^{Bt} \Leftrightarrow \delta(12\delta + 5) > 9$  which happens when  $\delta > 0.68$ .<sup>8</sup>

Figure 4 plots the incentive constraints of the two countries under price competition for the  $T$  only and the  $(t, T)$  case. Consider first the incentive constraints in the absence of a tariff. The LDC constraint under the  $T$  only case is upward sloping because as the discount factor increases, its willingness to pay a transfer increases as the future matters more. The DC constraint is downward sloping because the transfer it requires to prevent cartelization decreases with the discount factor. In the absence of a tariff, cooperation occurs in regions I and II where the discount factor is relatively high and the transfer required by the DC is acceptable to the LDC.

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<sup>8</sup>Recall that the same holds true under Cournot competition when  $n$  approaches infinity.

Now consider the incentive constraints under the  $(t, T)$  case (also plotted in Figure 4). Each country's incentive constraint under the  $(t, T)$  case lie below its corresponding constraint under the  $T$  only case. The LDC constraint shifts down when the tariff is available because its willingness to pay a transfer is lower when cartelization can be punished by a tariff increase. Similarly, the DC constraint under the  $(t, T)$  case is lower because the transfer it requires to prohibit cartelization is also lower when the LDC can punish cartelization via a tariff increase. Figure 4 shows that the DC constraint shifts down substantially more than the LDC constraint. The net effect is that when the transfer is the only available instrument, cooperation occurs in region I. If both instruments are available, cooperation occurs in regions II and III, but not in region I. Since region III is much larger than region I, cooperation occurs over a larger range of parameter values when both instruments are available to the LDC.

Since the LDC has no incentive to impose a tariff when DC firms compete in prices, the price competition case helps to isolate the punishment effect of a tariff.<sup>9</sup> Under Cournot competition, the LDC has an incentive to defect from cooperation to raise revenue via a tariff, so that the punishment effect is not the sole reason for using a tariff. A result analogous to Proposition 4 holds under price competition:

**Proposition 5:** *Under price competition, the following hold: (i)  $T_D^{Bt} < T_D^B$ ; (ii)  $T_L^{Bt} < T_L^B$ ; and (iii)  $T_D^{Bt} < T_L^{Bt}$  iff  $\delta > 0.68$ .*

A comparison between price and quantity competition also helps highlight the main implications of the alternative assumptions regarding firm behavior.

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<sup>9</sup>The punishment effect of a tariff under price competition can be quantified by  $T_D^t - T_D^B = \frac{5\alpha^2}{36}$ .

The following relationships are easy to show for all finite  $n$ : (i)  $T_D^* < T_D^B$ ; (ii)  $T_D^t < T_D^{Bt}$ ; (iii)  $T_L^* < T_L^B$ ; and (iv)  $T_L^t < T_L^{Bt}$ . Results (i) through (iv) can be summarized as follows: in general, the transfer levels (both required by the DC and those that the LDC is willing to make) are higher under price competition relative to the Cournot case. The common intuition underlying these results is that price competition is really attractive to the LDC because it results in marginal cost pricing. For the same reason, the DC loses a lot from this outcome and requires a large transfer to prohibit cartelization.

Also, the following limiting result holds:

$$\lim_{n \rightarrow \infty} (T_j^* - T_j^B) = \lim_{n \rightarrow \infty} (T_j^t - T_j^{Bt}) = 0.$$

for  $j = L, D$ . In other words, as the DC market becomes more competitive, the level of critical LDC and DC transfers under price and Cournot competition converge to each other. The underlying reason is that the product market outcome under Cournot competition converges to that under price competition as the number of competitors becomes infinitely large.

## 7. Conclusion

For any WTO antitrust agreement to be welfare improving for LDCs, it must address those dimensions of competition law enforcement that impose strong negative externalities on them. The legal status of export cartels in DCs is an example of a national antitrust law whose *sole purpose* is to benefit local firms at the expense of consumers in importing countries. Capacity constraints in many LDCs restrict their ability to apply national antitrust actions against foreign firms. As a result, it seems reasonable that a WTO antitrust agreement should require DCs

to alter their legislation to ban export cartels and practices with similar effects (Hoekman and Mavroidis, 2003). Our analysis suggests that such a ban would encourage trade liberalization by LDCs since they would not need market access restrictions to combat cartelization and could instead rely on the WTO's dispute settlement procedure to seek compensation against potential violations by DC firms.

At present, there is significant resistance in DCs to agreeing to such a ban and whether it can be negotiated in the WTO is an open question. Furthermore, the principle of reciprocity will likely require LDCs to make concessions in order to obtain such an outcome. The most obvious deal would involve LDCs trading market access (tariff bindings) for disciplines on export cartels (and similar practices) by DCs. We show that a mutually beneficial deal of this type can indeed be struck and that the more constrained the access of LDCs to trade policy the larger the transfers they would need to make, or, absent transfers, the greater the likelihood that they will be confronted with monopolistic pricing by DC firms. Furthermore, the scope for cooperation is maximized if LDCs can use both carrots (transfers) as well as sticks (tariffs). Thus, under a WTO mediated bargain between DCs and LDCs, the latter would be allowed to retain access to tariffs to enforce cooperation over the globally efficient outcome. Any tariff bindings (whether past or new) could then be reversed, if necessary, to enforce a finding by a WTO dispute settlement panel that a DC had violated its obligation to ban export cartels.

We should note that our analysis does *not* have implications for the more general debate on inclusion of multilateral disciplines for national competition law. In other words, our paper does not speak to proposals that all WTO members should have competition laws and abide by the principles of transparency and

nondiscrimination. By construction, our model does not give a major role to international disparities in market structure – something critical for assessing the case for such rules. Perhaps future research can shed light on these issues.

## 8. Appendix

Here we present the calculations underlying the main results of the paper:

### 8.1. Optimal LDC Tariff

After appropriate substitutions, welfare in the LDC can be written as

$$W_L(t) = \frac{X^2(t)}{2} + tX(t) \text{ where } X = nx = \frac{(\alpha - t)n}{n + 1}$$

The first order condition for the optimal tariff is  $X(t) = nt$ , which is the same as

$$\frac{\alpha - t}{n + 1} = t \Leftrightarrow t^* = \frac{\alpha}{n + 2}$$

### 8.2. Expressions for Profits and Welfare

Profits of a Cournot oligopolist equal

$$\pi(n, t) = (\alpha - t - nx)x = x^2 = \frac{(\alpha - t)^2}{(n + 1)^2}.$$

Substituting  $t = 0$  in the above gives  $\pi(n, 0) = \frac{\alpha^2}{(n+1)^2}$  whereas setting  $n = 1$  gives profits  $\pi(1, 0) = \frac{\alpha^2}{4}$ . Similarly, setting  $t = t^*$  and  $n = 1$ , gives  $\pi(1, t^c) = \frac{\alpha^2}{9}$ .

Next we derive the welfare expressions. We have

$$X^0 = \frac{n\alpha}{n + 1} \text{ and } p^0 = \frac{\alpha}{n + 1} \text{ which gives } W_L^0 = \frac{(X^0)^2}{2} = \frac{1}{2} \left( \frac{n\alpha}{n + 1} \right)^2$$

Similarly

$$X^* = \frac{n(\alpha - t^*)}{n + 1}; p^* = \frac{\alpha + t^*}{n + 1}; \text{ and } W_L^D = \frac{[X^*]^2}{2} + t^* X^* = \frac{n\alpha^2}{2(n + 2)}$$

Substituting  $n = 1$  in the expressions in the above equation gives

$$X^c = \frac{\alpha - t^c}{2}; \quad p^c = \frac{\alpha + t^c}{2}; \quad \text{and} \quad W_L^W = \frac{[X^c]^2}{2} + t^c X^c = \frac{\alpha^2}{6}$$

Finally, substituting  $t^c = 0$  in the above expressions gives

$$X^{W0} = \frac{\alpha}{2}; \quad p^{W0} = \frac{\alpha}{2}; \quad \text{and} \quad W_L^{W0} = \frac{[X^{W0}]^2}{2} = \frac{\alpha^2}{8}$$

### 8.3. Proposition 4

We have:

$$T_D^* - T_D^t = \frac{\alpha^2(n-1)^2}{4(n+1)^2\delta} - \frac{9\alpha^2(n-1)^2 - 5\alpha^2\delta(n+1)^2}{36\delta(n+1)^2} = \frac{5\alpha^2}{36} > 0$$

and

$$\begin{aligned} T_L^* - T_L^t &= \frac{\delta\alpha^2(n-1)(3n+1)}{8(n+1)^2} - \frac{2\delta\alpha^2n(n^2+n-1) - (2\delta+3n)\alpha^2}{6(n+1)^2(n+2)} \\ &= \frac{1(12n + \delta n^3 + 4\delta n^2 - 7\delta n + 2\delta)\alpha^2}{24(n+1)^2(n+2)} > 0 \end{aligned}$$

### 8.4. Price Competition

As noted earlier, under price competition,  $\pi(n, 0) = 0$  and  $t^*(n) = 0$ . Under cartelization, the same profit and tariff expressions continue to apply since it makes no difference whether the cartel chooses price or quantity. Consider the welfare expressions next. We have:

$$X^0 = \alpha; \quad p^0 = c; \quad \text{and} \quad W_L^0 = \frac{(X^0)^2}{2} = \frac{\alpha^2}{2}$$

Since  $t^* = 0$  and  $p^0 = c = p^*$ , we have  $W_L^D = W_L^0$ . Under cartelization,  $n = 1$ , and the expressions are the same as those derived under the Cournot case so that  $W_L^W = \frac{\alpha^2}{6}$  and  $W_L^{W0} = \frac{\alpha^2}{8}$ .

#### 8.4.1. Proposition 5

We have

$$T_D^B - T_D^{Bt} = \frac{\alpha^2}{4\delta} - \frac{(9-5\delta)\alpha^2}{36\delta} = \frac{5\alpha^2}{36} > 0$$

Further,

$$T_L^B - T_L^{Bt} = \frac{3\delta\alpha^2}{8} - \frac{\delta\alpha^2}{3} = \frac{\alpha^2\delta}{24}$$

Note that  $T_D^B - T_D^{Bt} < T_L^B - T_L^{Bt}$ , i.e., the availability of a tariff reduces the transfer required by the DC by a greater amount than it reduces the transfer the LDC is willing to pay. Finally, we have:

$$T_L^{Bt} - T_D^{Bt} = \frac{\delta\alpha^2}{3} - \frac{(9-5\delta)\alpha^2}{36\delta} = \frac{\alpha^2}{36} \frac{12\delta^2 - 9 + 5\delta}{\delta} > 0 \text{ iff } \delta > 0.68.^{10}$$

#### 8.4.2. Comparison of price and quantity competition

We have

$$T_D^B - T_D^* = \frac{\alpha^2}{4\delta} - \frac{\alpha^2(n-1)^2}{4(n+1)^2\delta} = \frac{\alpha^2 n}{(n+1)^2 \delta} > 0$$

and

$$\begin{aligned} T_D^{Bt} - T_D^t &= \frac{(9-5\delta)\alpha^2}{36\delta} - \frac{9\alpha^2(n-1)^2 - 5\alpha^2\delta(n+1)^2}{36\delta(n+1)^2} \\ &= \frac{n\alpha^2}{(n+1)^2 \delta} > 0 \end{aligned}$$

Next,

$$T_L^B - T_L^* = \frac{3\delta\alpha^2}{8} - \frac{\delta\alpha^2(n-1)(3n+1)}{8(n+1)^2} = \frac{\alpha^2\delta}{2} \frac{2n+1}{(n+1)^2} > 0$$

Further,

$$\begin{aligned} T_L^{Bt} - T_L^t &= \frac{\delta\alpha^2}{3} - \frac{2\delta\alpha^2 n(n^2 + n - 1) - (2\delta + 3n)\alpha^2}{6(n+1)^2(n+2)} \\ &= \frac{\alpha^2}{2} \frac{2\delta n^2 + 4\delta n + 2\delta + n}{(n+1)^2(n+2)} > 0 \end{aligned}$$

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<sup>10</sup>The other root of the polynomial  $12\delta^2 - 9 + 5\delta$  lies outside the interval  $[0, 1]$  and is irrelevant.

Finally,

$$\lim_{n \rightarrow \infty} T_D^B - T_D^* = \lim_{n \rightarrow \infty} \frac{n}{(n+1)^2} = 0 \text{ and } \lim_{n \rightarrow \infty} T_L^B - T_L^* = \lim_{n \rightarrow \infty} \frac{2n+1}{(n+1)^2} = 0$$

and

$$\lim_{n \rightarrow \infty} (T_D^{Bt} - T_D^t) = \lim_{n \rightarrow \infty} \frac{n}{(n+1)^2} = 0$$

and

$$\lim_{n \rightarrow \infty} (T_L^{Bt} - T_L^t) = \lim_{n \rightarrow \infty} \frac{2\delta n^2 + 4\delta n + 2\delta + n}{(n+1)^2(n+2)} = 0.$$

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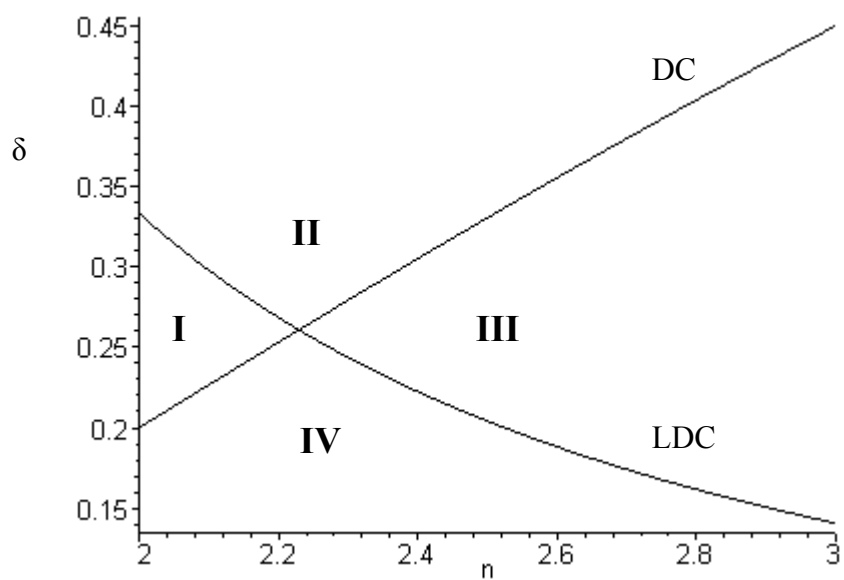


Figure 1: Cooperation under a tariff

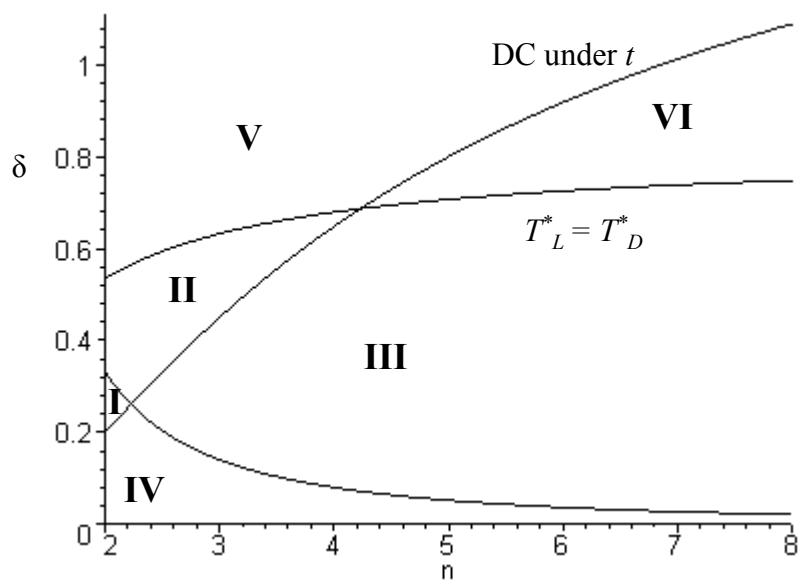


Figure 2: Comparison of the two instruments

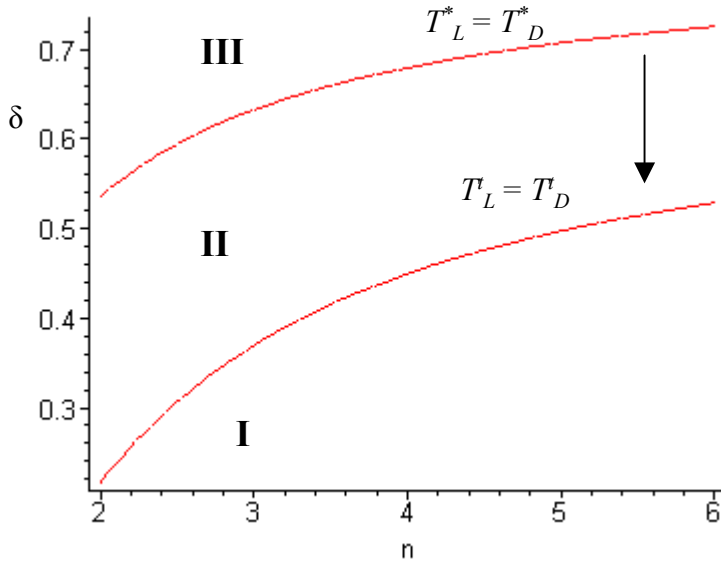


Figure 3: Cooperation under  $T$  versus  $(t, T)$

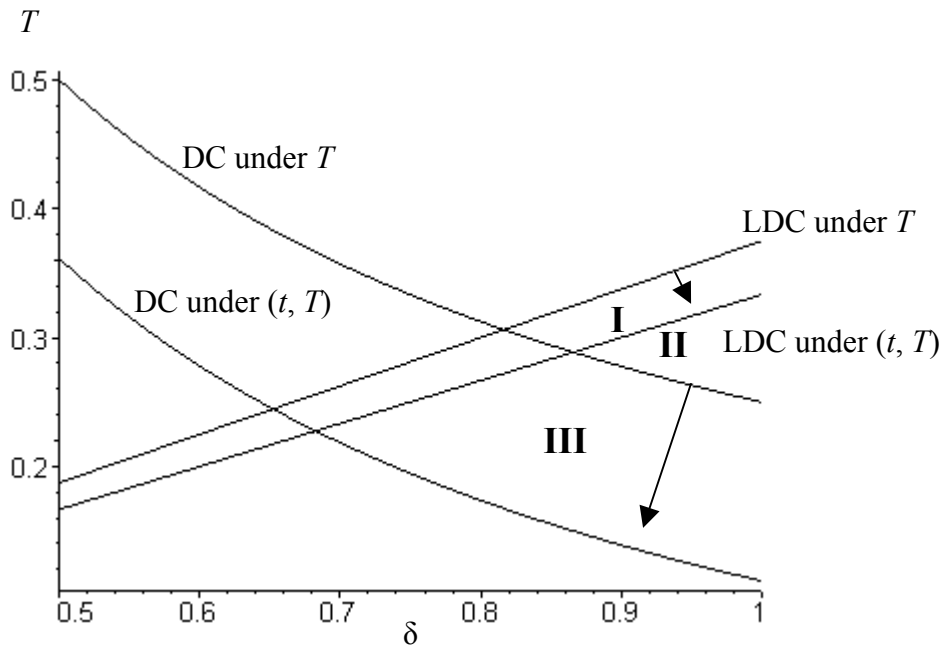


Figure 4: Cooperation under  $(t, T)$  with price competition